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PROCEDURES for CASTING RESINS

Introduction

When a decision has been made to cast either tools or parts, there are some basic guidelines that need to be followed to ensure the process goes smoothly. This informational bulletin is designed to help the user when they are casting urethanes or epoxies. Although there are some subtle differences between the two, the techniques are virtually the same. We will attempt to point out these differences as they come up. We'll assume the proper selection of materials to be used has already been made and the mold has been properly sealed and/or released. If you are unsure of the proper casting materials and release agents consult a PTM&W representative.

Checking Materials

After opening the containers, check material for any separation or settling that may have occurred during shipping. If necessary, mix thoroughly until uniform. It is generally recommended to use metal or plastic as a mixing paddle, particularly with urethanes. Wood or paper products may contain water or moisture, which can cause problems for urethanes particularly. Try to avoid mixing in excessive amounts of air. Secure the lid or cap back on the container immediately after use. For urethanes, it is recommended to spray dry nitrogen into the can if available. This keeps a blanket of dry, inert gas on the surface of the material to help extend its shelf life. This becomes more important as the material gets used, due to the increasing amount of "head space" created in the can.

Calculating the Volume

Determine the amount of mixed resin required for the casting. ("Mixed" meaning A & B combined) You'll need to calculate the cubic inches of the volume in which you will be pouring (height x width x length). Once this is accomplished, refer to the individual product data sheet for the selected resin/hardener combination under **"specific volume"** or **"volumetric weight ratio."** A number is given reflected in cubic inches/ per pound. Example: Area of casting is 2" x 10" x 10" totaling 200 cubic inches. Let's say the specific volume of the material listed is 25/cu.in/lb. If you divide the 200 cubic inches by specific volume of 25, you'll get 8. That means you need a total of 8 mixed pounds. This does not include waste. An extra 10%-15% should be factored in for waste. 15% waste brings our total to 9.2 mixed pounds. (Round up to 9.5)

NOTE: There is more than one method for determining the volume required. If you are unsure, consult a PTM&W representative.

Mix Ratio

Now that you know how much mixed resin is required, we need to determine the separate amounts of A & B to be used. Again, refer to the product data sheet for the **"mix ratio", parts by weight (pbw).** For example, let's assume the mix ratio is 100:60 pbw. That's 100 parts of resin, to 60 parts of hardener. (This relationship is the same regardless of the unit of measurement used i.e.; ounces, grams, pounds, etc.) Also, in most cases the "A" is the larger number of the 2 sides. We said earlier that we needed 9.5 pounds of mixed resin. If we divide 9.5 by 1.60 we get a total of 5.94 pounds. This is the amount of **resin or "A"** required. Subtract 5.94 from 9.5 and we're left with 3.56 pounds. This is the amount of **hardener or "B"** required**.** If by chance you had poured 5.94 pounds of resin or "A" into a cup and needed to determine how much hardener went with that, all you would do is "multiply" 5.94 x .60 and you would come up with same 3.56 pounds of hardener or "B."

NOTE: The mix ratio is probably the most important part of the process. It needs to be correct. Another important aspect to consider regarding mix ratios is if it is given by **"weight"** or **"volume."** Just because a product is listed as 100:50 by weight does not necessarily mean it is 2:1 by volume. If you do not have a scale to weigh your material and the volumetric mix ratio is not listed on the product data sheet, **do not assume or guess.** If you are unsure how to calculate the mix ratio, or need a volumetric mix ratio, please consult a PTM&W representative.

Weighing and Mixing

We're now ready to **"weigh"** the material. Again, it is advised to use metal or plastic containers to mix the material in. Paper containers can be purchased with a sealed coating on the inside. Try to avoid waxed containers since the wax can be scraped off during mixing. Unsealed paper containers can allow the lower viscosity (thin) materials to soak in and eventually through, potentially throwing off the mix ratio. Paper also tends to soak up moisture, which again, is bad for urethanes. After zeroing your scale (tare) to compensate for the weight of the container, pour in the resin. (If your material came in 5 gallon containers or full gallons, it's easier to pour some off into smaller more manageable containers for the weighing process) Re-zero your scale and repeat with the addition of the hardener.

The **"mixing"** process can be accomplished by hand or mechanically. Mixing by hand offers better control and introduces the least amount of air. For large batches or very highly filled epoxies, a mechanical mixer will be easier but tends to whip more air into the batch. It's very important that the sides and bottom of the container, as well as the mixing paddle, are scraped thoroughly several times during the mixing process. Low viscosity hardeners tend to float on the surface then migrate toward the sides of the cup potentially leaving unmixed material. This can lead to soft spots in your casting. As a precautionary measure, particularly for high viscosity materials (thick), it is recommended that the material be poured into a second container (known as **"double cupping"**) and be re-mixed. The price of an extra cup will seem very insignificant should you have to go back and repair or redo the casting.

Degassing or Pressurizing

Provided you have the necessary equipment, the practice of removing air from the casting system is always highly recommended. There may be situations where it is not practical or the resin system does not allow the necessary time to accomplish this, but the quality of the casting will always be better if you can. Degassing or deairing is a method where resin (mixed or unmixed) is placed in a sealed glass/plastic bell jar or tank with a see-through lid that is connected to a vacuum tank with a vacuum gauge.. When the vacuum pump is turned on virtually all the air inside the tank is evacuated. As the air is being evacuated (recorded in inches of mercury on the vacuum gauge, 29.92 being a perfect vacuum) the resin inside the tank begins to bubble. As the vacuum increases so does the size of the bubbles and the material begins to rise in a big foamy mushroom head. Normally this movement does not even begin to occur until the gauge reads 28 inches. Once this foamy head fully rises (this can easily be 10 times the original height of the material) it will collapse or break and begin to decrease in height and bubble size, rapidly in most cases. After this collapsing or breaking, **"pot life and mass"** will dictate how long you allow the **mixed** material to continue bubbling. It is not necessary for all the bubbles to disappear. Things to consider about degassing: **If your material does not collapse back down, you have not degassed your material.** This may mean your pump is inadequate or you have leaks. You'll need a container that is many times larger than the material it is holding to allow for the rising. Otherwise it will overflow the container. This is also why you need to be able to see in the tank or through the bell jar. Additionally, this takes time off the **"pot life"** of your resin system, due to the fact it's an extra step, plus the longer the resin sits in mass, the faster it will react.

Pressurizing is a different approach to removing air, usually reserved for rapid prototyping parts. It's a little misleading because the air bubbles are not actually removed; rather they're crushed until they go into solution and disappear. Equipment necessary for this process is either an **autoclave**, which can be expensive, or a **pressure pot,** which is used for painting or aiding in spraying higher viscosity material. Both need to be certified as pressure vessels. The pressure pot is far less expensive but limited in size, usually up to 55 gallon. In this method the whole mold, with the resin cast within, is placed in the sealed pressure tank and air is forced in. Pressures of 20-80psi will generally eliminate the bubbles. Limitations of pressurizing are obviously the size of your tank and mold. You have to leave the mold under pressure until the resin completely gels firm. Otherwise, if the pressure is relieved, the bubble will return to its original size. All that said, depending on the materials used and complexity of the mold, air bubbles can still occur.

Pouring Tips and Techniques

If you do not have vacuum degassing equipment or a pressure tank it does not mean you can't have quality castings. First, the surface of the pattern you are duplicating should be facing up, allowing the air to move away from it or towards the back of the casting. Once a material is mixed, if it is allowed to sit for 5 or 10 minutes in the cup before pouring (pot life permitting) the air bubbles will migrate to the surface, allowing you the opportunity to remove them. This can be accomplished by lightly brushing the surface, bursting the bubbles. Use of a heat gun or propane torch will also burst them. Extra care must be taken when using heat of any kind, particularly flame. Do not linger in any one area when applying this technique, it could prematurely cause the resin to gel or create "hot spots." These same techniques can also be employed on the back surface of the casting after the mold is filled. Warming your resin system will lower its viscosity allowing it to flow and release the air easier. Warming your mold will also reduce the surface tension that is present, again allowing for better flow and releasing of air. Keep in mind when you warm your resin you are speeding up the reaction of it. There is a 10°C (18°F) rule we frequently refer to: As a rule or thumb, for every 10°C increase or decrease in temperature, the pot life of the resin system is either halved or doubled. On cold days your resin will be thicker. A good general temperature to keep your mold and resin at is between 80°F-90°F. With very highly filled systems such as epoxies, painting the surface of the mold with a coat of the resin prior to pouring will not only help flow but minimize air entrapment that wants to occur in corners and other detailed areas such as lettering. With regard to corners or sharp angles, it's recommended (in your mold design) to incorporate a radius whenever possible to reduce the effect of inherent stress that can lead to cracking. Vibration of the mold is another method for getting the air to move away from the surface. When pouring any mold, it's advisable to elevate one end and pour from the low end. This forces the resin to push the air out ahead of it. This is particularly true in closed molds where it is imperative the resin flows at such a pace and manner not to get ahead of itself creating trapped air pockets. The vents would be positioned at the highest point(s) and the resin poured from the lowest point, or the bottom. In such a case, the pour tube, or funnel, has to be taller or higher than the highest point of the mold, with the capacity to hold enough volume to force the resin to flow. Pressure can be applied to the tube (5-8 psi) to help push the resin. Other techniques for breaking the air while pouring are allowing the resin to run very slowly down a long trough, or in a very long, thin stream, stretching the resin causing the air to break. In all cases the resin should be poured in a slow steady manner.

Curing and De-molding

Most urethane and epoxy casting resins will cure fully at room temperature without the use of heat. There are exceptions to this of course, generally in long pot life, high temperature epoxies and a few room temperature systems. Having said that, you will always achieve better physical properties, and higher temperature performance when given a heat cure. An overnight cure of 18-24 hours is generally enough time to allow the casting to be de-molded. Temperature again, will be influential in this regard, as well as the speed or pot life of the system you poured. For instance, slower or longer pot life systems may take up to 36-48 hours. Temperatures below 70°F will slow down the curing process for many systems causing them to be "brittle," "cheesy," or even still rubbery or tacky. If you attempt to de-mold a casting in this state, it's very possible you will experience any number of problems including, cracking, chipping, breaking, increasing the likelihood of damage removing it from the mold. That means it either has to sit longer or the temperature needs to be elevated. In most cases 90°-100°F is sufficient, particularly if it can be left overnight. If an oven isn't an option for you, you can tent the entire mold with plastic, even surround it with Styrofoam or cardboard to insulate it. Then place 100-watt light bulbs, space heaters, heating lamps or blankets in and around it, anything to bring the temperature up. When applying heat use caution, try to avoid concentrated hot spots. The use of a fan works well for circulation. When using a high temperature system that calls for a **"post cure"** refer to the product data sheet post cure schedule. As always if you're unsure, consult your PTM&W representative. **Good luck!**